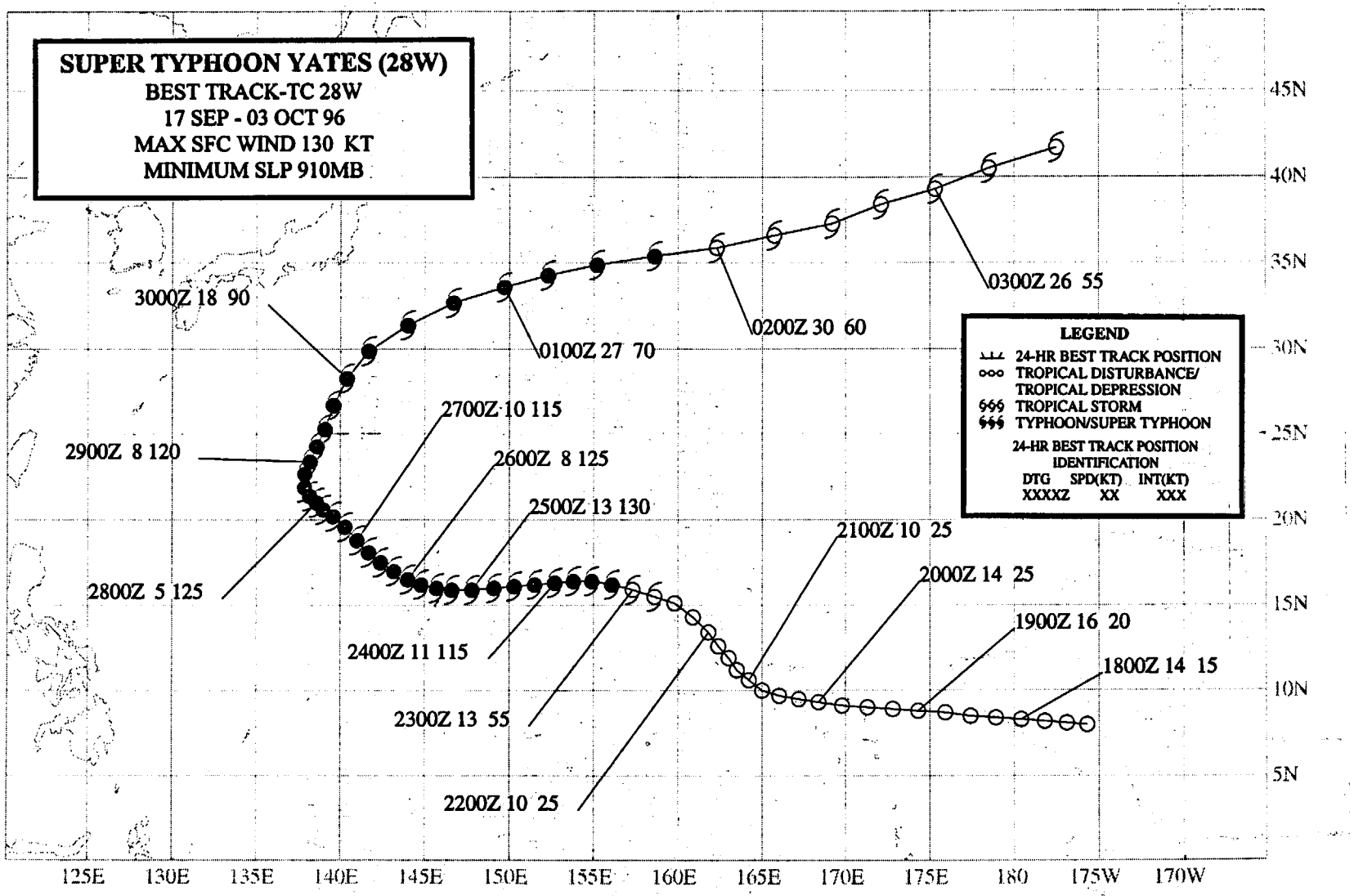
SUPER TYPHOON YATES (28W)
BEST TRACK-TC 28W
17 SEP - 03 OCT 96
MAX SFC WIND 130 KT
MINIMUM SLP 910MB
3000Z 18 90
0100Z 27 70
0200Z 30 60
0300Z 26 55
2700Z 10 115
2900Z 8 120
2600Z 8 125
2500Z 13 130
2800Z 5 125
2100Z 10 25
2000Z 14 25
1900Z 16 20
1800Z 14 15
2400Z 11 115
2300Z 13 55
2200Z 10 25
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/ TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XXX
45N
40N
35N
30N
25N
20N
15N
10N
5N
125E
130E
135E
140E
145E
150E
155E
160E
165E
170E
175E
180
175W
170W

SUPER TYPHOON YATES (28W)

I. HIGHLIGHTS

While passing between Saipan and Anatahan (two islands in the Northern Marianas), Yates was observed with Guam's NEXRAD. Although Yates became a super typhoon, its surface wind field was relatively compact, and it possessed a very small satellite-observed eye for much of its life. Yates and Zane (29W) developed in the same monsoon trough, at approximately the same time, and recurved simultaneously along similarly shaped and spatially-proximate tracks.

II. TRACK AND INTENSITY

During early September, five TCs — Sally (23W), TS 24W, Tom (25W), Violet (26W), and Willie (27W) — formed in the monsoon trough. This very active monsoon trough moved northward, became reverse oriented, and by the final week of September had migrated to a relatively high latitude. As this monsoon trough exited the tropics, a new monsoon trough formed at low latitudes, and was the site of development for the next two TCs in the WNP: Yates and Zane (29W).

The tropical disturbance which became Yates was mentioned on the Significant Tropical Weather Advisory as early as 170600Z September, when a persistent area of deep convection was observed at low latitude just east of the international date line. At this time the WNP was still dominated by the reverse-oriented monsoon trough which contained Tom (25W), Violet (26W) and Willie (27W). The low latitudes of the WNP were dominated by high pressure and low-level easterly flow, and the pre-Yates tropical disturbance was the only significant area of deep convection which was deemed to have any chance of becoming a TC. During the next three days, this disturbance traveled westward into the Marshall Islands. Amounts of deep convection associated with this disturbance began to increase, along with a gradual increase in the amount and extent of deep convection throughout the rest of Micronesia. On 21 September, a small area of persistent deep convection consolidated northwest of Kwajalein. Visible and water-vapor satellite imagery indicated good upper-level anticyclonic outflow over this disturbance, prompting the JTWC to issue a TCFA at 210100Z. Over the next 24 hours, the small system showed no signs of development, but maintained its organization. Thus, a second TCFA was issued at 220100Z. During the night of 22 September, the pre-Yates tropical disturbance rapidly acquired well-organized cyclonically-curved convective cloud bands surrounding a small area of persistent deep convection over the LLCC. Based upon this improvement in convective organization, the first warning on Tropical Depression (TD) 28W was issued valid at 221800Z. Within three hours after its issuance, the first warning was amended to indicate that TD 28W was a tropical storm. The amended warning stated:

"Tropical Storm Yates (28W) is moving west-northwestward at 14 knots. Justification [for amendment]: this warning has been amended based on intensity. Satellite analysis indicates that this system is [of] tropical storm intensity. Due to its small size and diffluent [divergent] winds aloft, rapid intensification is expected. . . ."

Yates did indeed intensify rapidly. During the period 221800Z to 231200Z it increased from a minimal tropical storm to a typhoon with an intensity of 115 kt (59 m/sec). The equivalent pressure fall of 57 mb during this 18-hour time period (or 3.2 mb/hr) met the criterion for explosive deepening (i.e., a decrease in the minimum sea-level pressure of a TC of 2.5 mb/hr for at least 12 hours) as defined by Dunnavan (1981). At 250000Z, Yates reached its peak intensity of 130 kt (67 m/sec) (Figure 3-28-1). Yates was a minimal super typhoon for only six hours, and then its intensity fell slightly to 125 kt (64 m/sec) as it passed between the islands of Saipan and Anatahan. During

the four-day period 250000Z to 290000Z, Yates remained a powerful typhoon as its intensity fluctuated slightly between 115 and 125 kt (59 to 64 m/sec) and maintained a very small eye which was, at times, cloud filled.

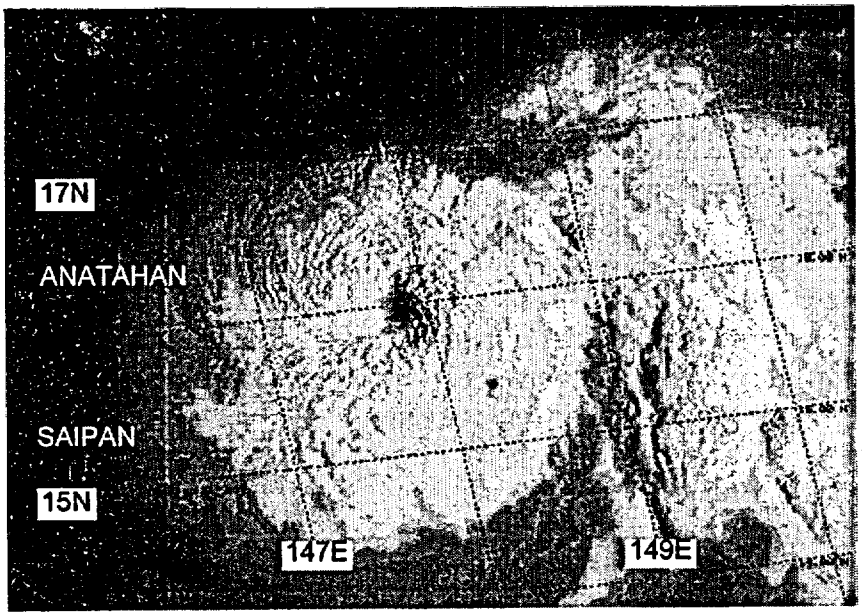

Figure 3-28-1 Yates at peak intensity of 130 kt (67 m/sec) (242319Z September visible DMSP imagery).

Late on 28 September, Yates began to recurve. It moved slowly toward the north-northeast on 29 September, and then on 30 September, it entered the deep-layer westerly air flow of the midlatitudes, turned more toward the east and accelerated. The final warning was issued valid at 011800Z October as the system neared the completion of its extratropical transition. Yates became a powerful extratropical low in the North Pacific after it crossed the international date line (Figure 3-28-2).

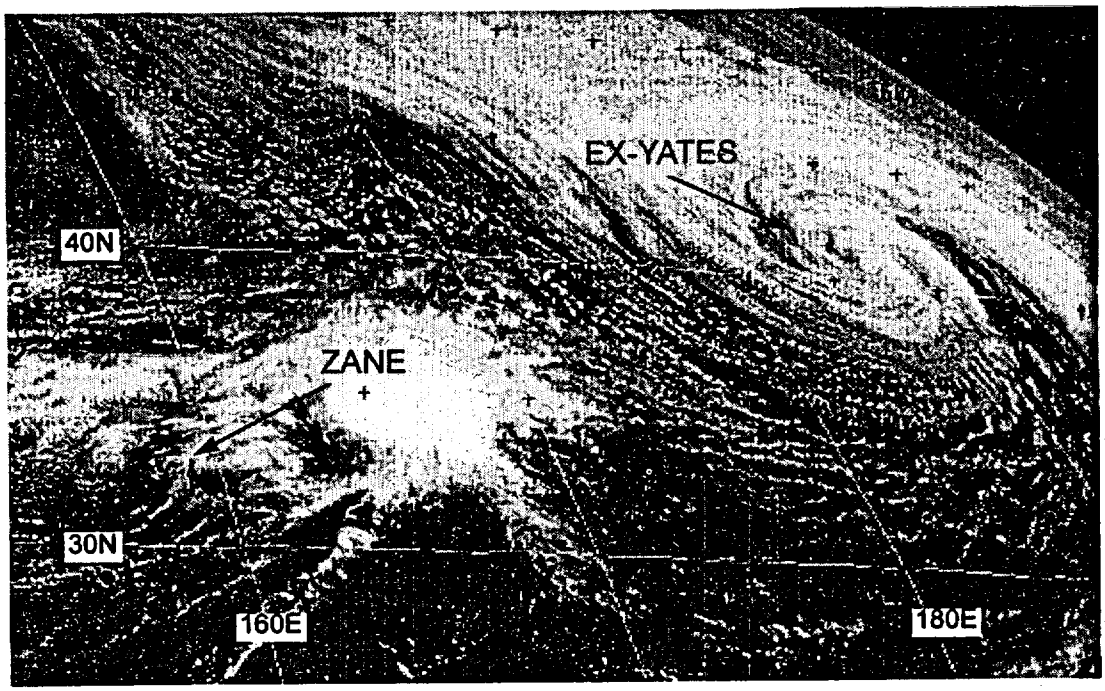

Figure 3-28-2 After recurvature, Yates became an intense extratropical low in the central North Pacific, while Zane (29W) slowed and dissipated (032331Z October visible GMS imagery).

III. DISCUSSION

a. *Persistent pin-hole eye*

Visible and infrared satellite imagery indicated that Yates possessed a very small, or "pin-hole", eye (i.e., a diameter of 10 nm or less) throughout most of its life. Many typhoons which acquire a pin-hole eye usually evolve to possess a larger eye (see the summaries of Super Typhoon Dale (36W) and Super Typhoon Ward (1995)). The evolution from pin-hole eye to larger eye typically begins with the formation of concentric wall clouds. Having formed concentric wall clouds, the outer wall cloud contracts as the small eye and inner wall cloud collapse. Eye wall replacement processes are described more fully by Willoughby (1982, 1990). Yates was somewhat unusual in that it retained a pin-hole eye for four days.

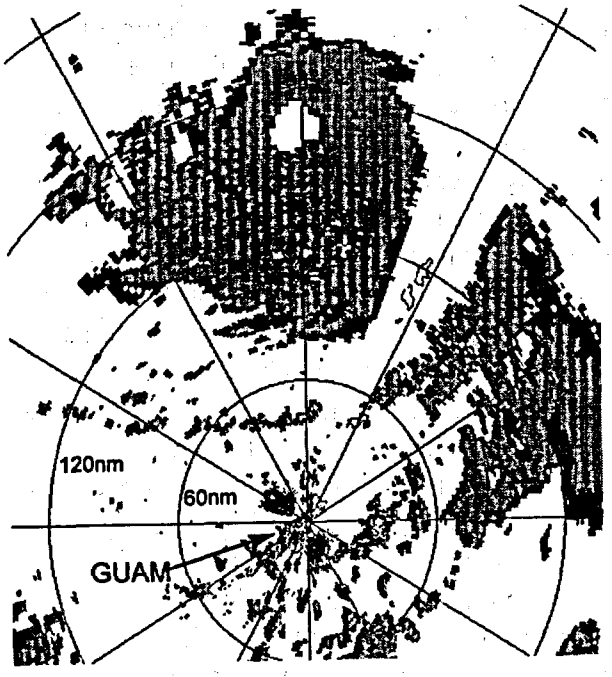

Figure 3-28-3 Yates maintained a well-defined 18 nm (33 km) diameter eye on NEXRAD as it passed to the north of Guam (251844Z September base reflectivity NEXRAD product).

b. *Passage though Guam's NEXRAD coverage*

On 25 September, Yates passed between the islands of Saipan and Anatahan. Its small eye passed approximately 50 nm (100 km) to the north of Saipan, 20 nm (40 km) to the south of Anatahan, and 155 nm (290 km) to the north of Guam. Yates was close enough to Guam to be scanned with Guam's NEXRAD (Figure 3-28-3). The following comments were received in an after-action report by the Andersen AFB NEXRAD operators:

"Yates' well-defined circular eye became visible on radar [at] 25/0131Z shortly after being upgraded to STY intensity and continued to track west at 14 kt average. [Its] symmetrical eye, with an average diameter of 18 nm [33 km], was well surrounded with up to ninety percent high reflectivity wall cloud. . . . [it] went out of range on 26/0834Z. . . Yates never came within [the] 124 nm (230 km) velocity range. . . Reflectivity products were sufficient to fix its eye and movement with a high degree of accuracy. . . ."

It is interesting to note that in Yates' case, the radar-observed eye was larger than the satellite-observed eye. On satellite, the eye diameter was approximately 10 nm (18 km) when not cloud filled. That the pin-hole eye of Figure 3-28-1 had a larger diameter on radar than that which was seen on the satellite imagery implies that cirrus of the wall cloud was obscuring the eye somewhat.

c. *Segregation of TCs into families based upon monsoon trough evolution*

The tendency of the monsoon trough of the WNP to form and then migrate northward lends itself to a natural segregation of TCs into "families" with the commonality among the TCs within each "family" being that they were associated with the same monsoon trough. The five-TC sequence of early September — Sally (23W), TS 24W, Tom (25W), Violet (26W), and Willie (27W) — all had in common an origin within the same monsoon trough. By late September, this monsoon trough moved northward, became reverse oriented, and migrated to higher latitude as TCs Tom (25W) and Violet (26W) carried it with them out of the tropics. As this trough exited the tropics, a new monsoon trough formed at low latitudes, and was the site of development for the next two

TCs in the WNP: Yates and Zane (29W). Yates and Zane therefore comprise another "family" by virtue of their development within the same monsoon trough.

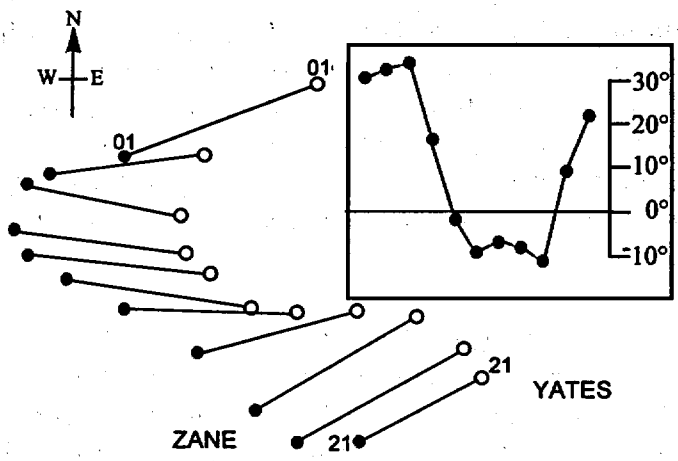

Figure 3-28-4 A schematic illustration of the similarly shaped and spatially proximate recurving tracks of both Yates and Zane (29W). Thin lines connect the TCs at 24 hour intervals beginning at 210000Z September and ending at 010000Z October. The inset shows the bearing of Yates from Zane at 24-hour intervals during the same time period. Positive values indicate Yates north of Zane.

d. *Direct, semi-direct, and indirect TC interaction*

Like Tom (25W) and Violet (26W) before them, Yates and Zane moved on nearly identical spatially-proximate recurving tracks (Figure 3-28-4). The inset of Figure 3-28-4 shows the bearing of Yates from Zane. Note the initial cyclonic change of bearing, followed by a period of anticyclonic change of bearing, then as Yates recurved, the change of bearing was once again cyclonic. Although these two TCs approached to within 780 nm (1450 km), there is little evidence that the TCs were mutually advecting each other (i.e., the Fujiwhara effect) during any of the periods of relative cyclonic orbit. In the Systematic and Integrated Approach, there are three basic kinds of TC interactions: direct (a mutual cyclonic orbit resulting from the TCs being advected by each other's outer winds), semi-direct (a mutual cyclonic orbit resulting from the alteration by one TC of the steering flow between the other TC and the subtropical ridge), and indirect (i.e., a mutual anticyclonic orbit resulting from the establishment of a ridge between the two TCs). Yates and Zane (29W) had motion characteristics suggestive of semi-direct and indirect TC interaction. The mutual anticyclonic orbit of Yates and Zane during the period 23 to 26 September (manifested in a south-of-west track for Yates) are typical of indirect TC interaction. The periods of mutual cyclonic orbit at the beginning and at the end of the tracks is consistent with semi-direct TC interaction. It is often difficult to differentiate between semi-direct and direct TC interaction, but one clue is often the separation distance. True direct interaction of two TCs usually occurs when the TCs are within 780 nm (1450 km) of each other. Yates and Zane were at this threshold, and it is possible that they may have interacted directly, especially at the end of their tracks when the cyclonic orbit increased rapidly.

TC interaction often results in complicated forecast scenarios. When Yates and Zane came abreast of one another at the same latitude, it was unclear which of the two would recurve first. Zane (29W) had been gaining latitude faster than Yates, and once south of Yates, it moved so as to be at a higher latitude. When Zane slowed near Okinawa, Yates turned to the north, accelerated, and moved to a higher latitude relative to Zane. Yates then recurved ahead of Zane.

IV. IMPACT

Because of Yates' small size, there was only minor damage on Saipan and Anatahan. On Saipan, Yates felled several trees and caused minor flooding. On Anatahan, where estimated winds of 80 kt (41 m/sec) were reported, tin roofs were blown off houses and the entire taro crop was destroyed. Only a handful of people live on the island and they were reported safe and in possession of plenty of food after the cyclone's passage.